# Manual

## I - Getting started

### *Overview*

ZeNeuSound  is a tool to sonify neural imaging data. It uses a system of regions of interest (ROI) on which parameters are computed then used to control the outcoming sound. Currently up to 200 ROIs can be used at the same time.

The principle of the sonification is to let each ROI play a single note, which amplitude is driven by the mean value of the ROI (« Signal ») at the current frame. The ROIs are put in *clusters*, defined by their color and number, each ROIs in a given *cluster* play the same note. The allocations of the *clusters*, and associated notes is left to the user, and another *cluster* related parameter (mean value, etc) can be mapped to the brightness of the sound.

The data used for the sonification are the mean values on each ROIs over time computed with FIJI and processed with the provided Matlab scripts, and the ROI set from FIJI processed with the matlab script.

Thus the patcher requires :

- The data
- The ROIs locations
- The notes attributed to each  *cluster*
- The video associated with the data

You can freely allocate ROIs to up to nine *clusters*, set notes for the *clusters*, change and save the mapping, and select the sound produced by the different *clusters*.

To lauch the program, double click on zebraSound.maxproj. At the start, the program loads a default set of data with the associated *clusters*.

### *Installation*

The software runs with Max/MSP (Cycling `74) and can be downloaded here. Max/MSP is a commercial software, however a trial version allows you to run patchers and to save changes for up to 31 days.

To install the sofware unzip the .zip file in a new folder. It contains all the files needed to launch the program.

The *other* folder contains the scripts needed to process the data in order to use them with Max/MSP. There are three scrpts : exportClusters.m (cluster file), exportROI_txt.m (ROI file) and read_resultsImageJ.m (data file). Credit for the readImageJROI.m function goes to Dylan Muir[1].

1 https://github.com/DylanMuir/ReadImageJROI

A default data set is included : mean_raw.txt (data) and roitext.txt (ROI location on the video), as well as few note sets and the associated clusters.

# II - The interface

The interface is built around two panels, the *Main panel* from which you can access the main information and interactions and the *Mapping panel* to modify the mapping,

## ***Main panel***

The *Main panel* is the main interface, where you can access the different panels and the main options to control the sonification.

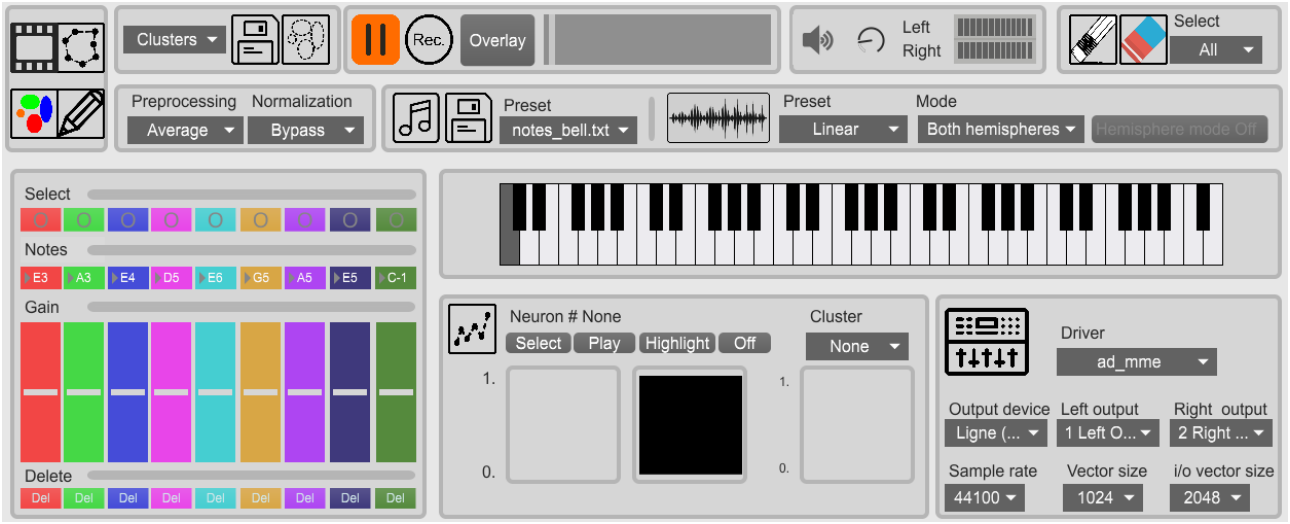
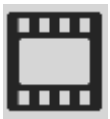



*Figure 1: Main panel*

This is divided into several areas : *Input files, Clusters, Video, sound. Tools, data processing, sound, mapping, clusters interface, note selection, graph section and driver section.*

### 1) Data

This section controls the data sets for sonification.

-  : loads video
-  : loads ROI set
-  : loads clusters set

-  : loads set of fluorescence signals

### 2) Clusters


*Figure 2: Clusters section*

This section allows to manage the three available sets of clusters. From left to right :

- The *menu* allows to switch cluster sets.
- Save current cluster set
- Reset cluster sets

### 3) Video


This section manage the video playback. From left to right :

- *Play/pause*
- When clicking *record* (rec) a recording of both audio and video begins. Another click ends the recording and save the file.
- *Playback control*

### 4) Sound


*Figure 3: sound interface*

From left to right :

- Turn on/off the sound processing.
- Volume control
- Left/Right output vu-meter

### 5) Sonification control

This section controls the sonification : groups, notes, mapping, etc.

- *Groups interface (fig 3) :* the nine colored tracks contain the controls for the different groups. Each track contains, from top to bottom:
  - A *slider* to control the volume of the group
  - The note attributed to the group (can also be used to choose the note)
  - A *select button* to select or deselect the group
  - A *Del* button to delete the group

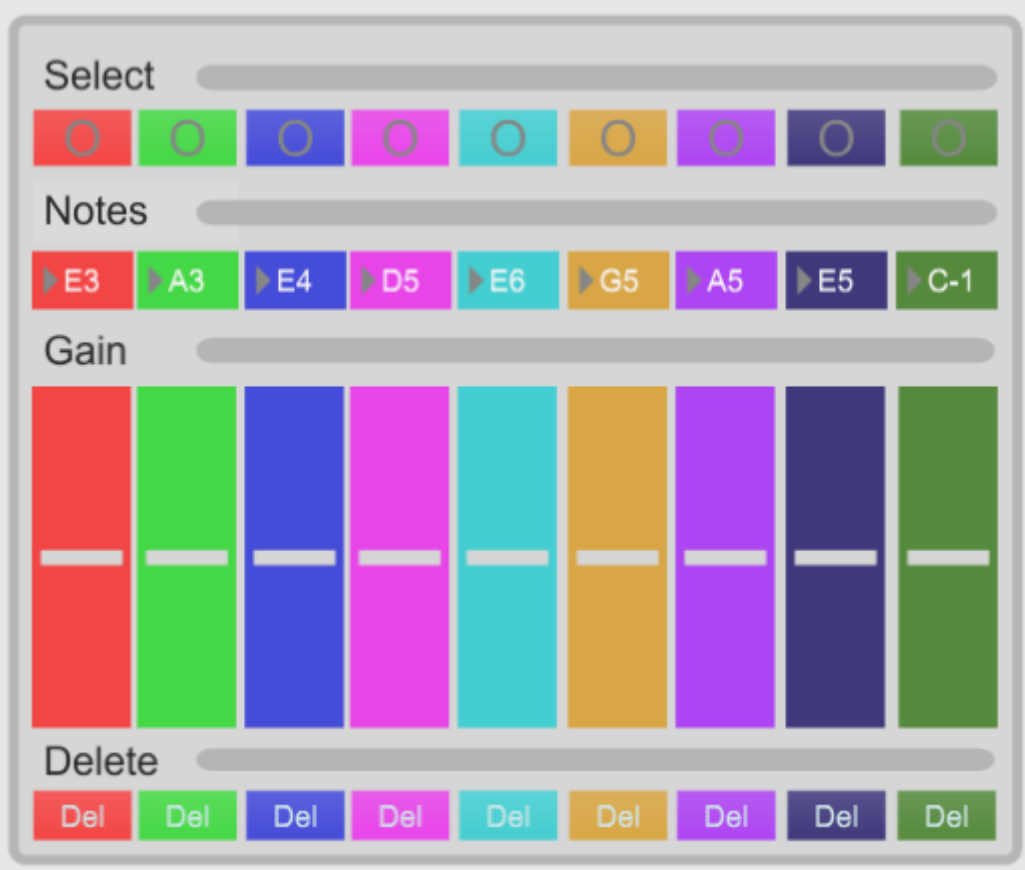



*Figure 4: clusters interface*

### 6) Tools


*Figure 5: tools section*

The tools section allows to exclude neurons from the sonification, and to select which neurons to hear (plotted neurons only, plotted clusters only, all neurons). From left to right :

- Enter *del mode* to exclude neurons from the sonification
- Remove *all* neurons from the sonification
- *Menu* to select which neurons to hear.

### 7) Processing section


*Figure 6: processing section*

This section allows too choose the preprocessing method (first *menu*) and the normalization method (second *menu*)

### 8) Graph section


*Figure 7: graph section*

This section allows to plot the normalized activity of a single neuron and the group parameter associated with a cluster. From left to right :

- *Graph panel*
- Select button : click the button then on the desired neuron to choose it.
- Play/pause button : play/pause the plotting
- Hilight  button : remind which neuron is beeing tracked
- Off button : turn off the graph.
- *Menu* to select a cluster to plot.

### 9) Driver section

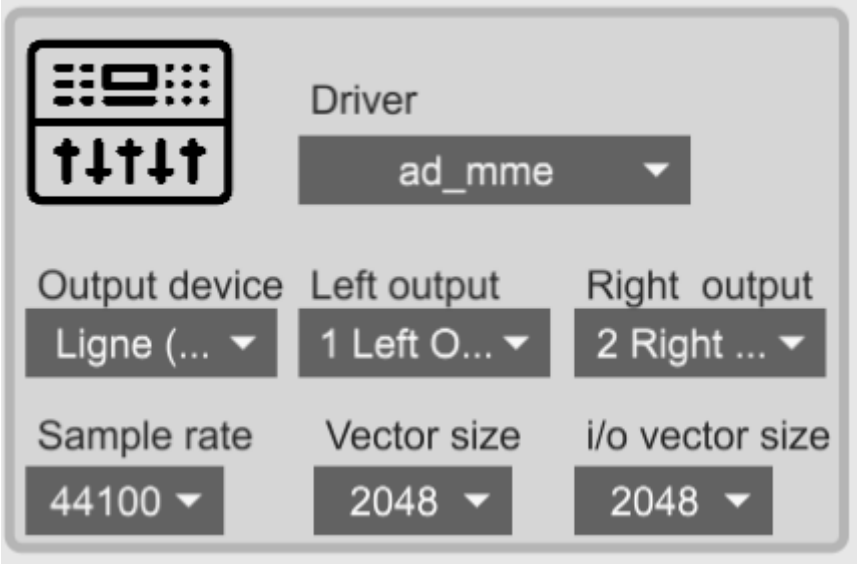



*Figure 8: Driver section*

This section allows to set the audio parameter (advanced users).

### 10) Mapping section


*Figure 9: Mapping section*

This section allows the user to modify the notes and the sound produced by the sonification. From left to right :

- *Load notes button* load a set of notes to use.
- *Save notes set* : save the current set of notes.
- *Notes presets menu* : a list of set of notes to use.
- *Mapping panel* : open the mapping panel.
- *Mapping presets menu* : a list of mapping (i.e. relation between data and sound) to use.
- *Mode menu* : you can choose to hear only the left hemisphere, the right hemisphere, or both.
- *Hemisphere mode on/off* : in hemisphere mode one hemisphere is pitched one octave higher

## ***Mapping panel***

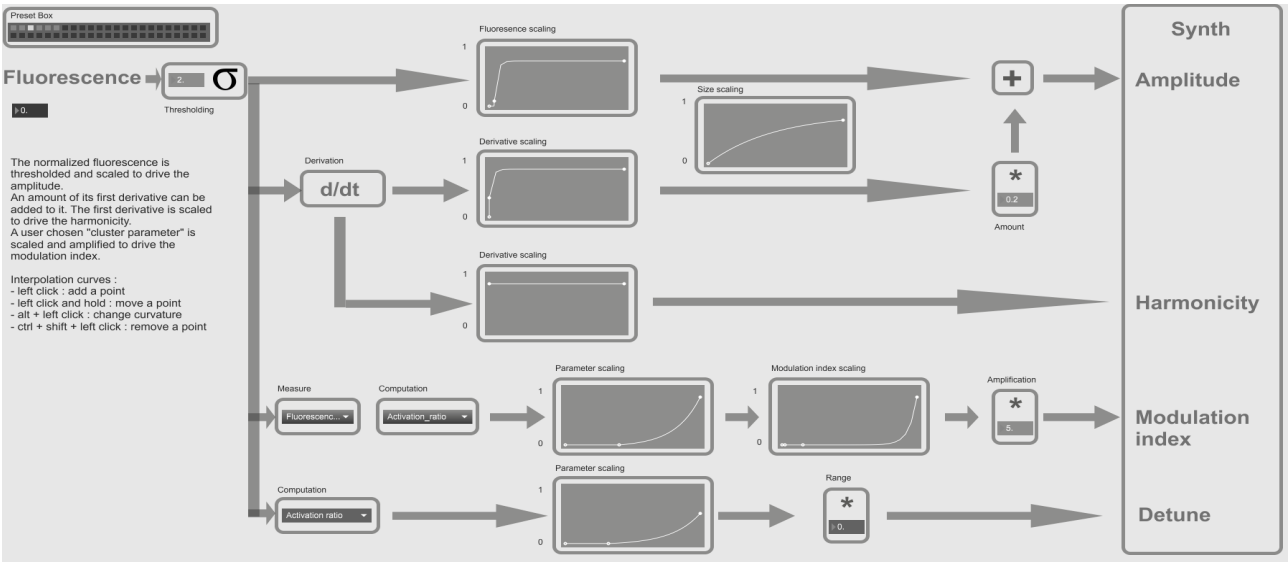



*Figure 10: Mapping panel*

The Mapping panel allows you to control the mapping (i.e. adjust the parameters of the data to control the parameters of the sound), the scaling functions and the parameters used. You can access it by clicking on the *Mapping* button on the *Main panel*.

The panel is presented as a flow chart where you can follow the signal from the normalization to the synthesizer.

From top to bot you can find :

- The amplitude line
- The harmonicity line
- The modulation index line
- The detune line

We call $f(t)$ the incoming, processed and normalized signal.

The normalized signal is fed to the *Threshold* to only conserve the activated ROIs. The incoming signal $f(t)$ is threshed with a value corresponding to the standard deviation of the signal multiplied by a coeficient. The *number box* allows you to set the coeficient.

All the curves on this panel are *scaling curves* which are used to scale the values. They make the coming value, the absissa, corresponds to the output value, the ordinate.

- Add a point : click
- Remove a point : shift + click
- Change curvature : alt + click
- Move point : hold click

- *Amplitude modulation line* : this line shows the mapping of each ROIs signal to the amplitude of the sound signal.

    - The threshed signal is scaled using a *scaling curve* to make the activation more easily perceived.
    - The signal is then *Sharpened* adding its derivative (d/dt). The *number box* allows to change the amount of derivative added. This is to enhance the perception of events in the datas set.
- *Modulation index line* : this line describes the mapping to the modulation index. The threshed signal runs through it.
    - *Measure menu* : which value is used for computation
        - Activation value : the normalized signal is used.
        - Speed value : the derivative of the normalized signal is used
    - *Computation menu* : what parameter is computed
        - *Average* and *average derivative*: the mean value over the whole cluster (or its rate of change computed over three frames) which contains the ROI is mapped.
        - *Activation ratio* : the ratio between the number of activated ROIs (i.e the choosen measure is non zero) and the total number of ROIs in the cluster is mapped.
        - *Activation ratio rate of change* : the first derivative (computed over three frames) of the activation ratio is mapped.
    - The outcoming signal goes through two *scaling curves.*
- *Detune line* : this line describes the mapping to the detune effect between hemisphere. Based on the chosen parameter, neurons in the left hemisphere are pitched higher, and the ones in the right hemisphere are pitched lower.
    - *Menu* : select the parameter to use. The value used for synthesis is the absolute value of difference between left and right parameter.
    - Please note that the parameters are cluster based : the same detune will apply to each neurons in a given cluster and a given hemisphere.
- *Presets* : a set of parameter can be saved with shift + click on a square. Please keep in mind that an overwritten preset cannot be retrieved : overwriting a preset is permanent if the patcher is saved.

# III – Interacting with the patcher

This section describes how to interact with the software : loading datasets, managing ROIs and clusters, and modifying the mapping.

## *Loading different datasets*

The first thing to do is to load a dataset which consist of:

- The data (fluorescence signals) to sonify
- The ROIs

- The associated video
- Cluster file (optional)

Please ensure all the loaded files have been processed with the provided Matlab script, as they need to be properly formatted to use with Max.

Procedure :.

- Load the video : click *Load video button* on the *Main panel*. The message read_new_video: [video] 1 appears in the console.
- Load the ROIs : click *Load ROI file button* on the *Main panel*. The message
  Read_new_ROI: bang
  appears in the console
- Load the data : click *Load data button* on the *Main panel*. The message Read_new_data: bang should appear in the console.
- Choose the normalization and the processing : select the normalization and the processing to use with the normalization and processing menus on the *main panel*.

To load a cluster file click *load cluster file button*. This should be done after loading the ROIs.

## ***Attributing groups, notes and using clusters***

Every ROIs within a cluster produce a sound, an ROI not allocated to a cluster will not produce any sound.

The different ROIs are represented by colored dots on the display, the gray ones beeing the unallocated ROIs, and the colors represent the clusters.

The basic idea is that when a cluster is selected every cluster related actions (such as adding an ROI, changing the note) are performed on *this* cluster. Up to nine gr cluster oups can be used at the same time.

*Adding* an ROI to a cluster:

- Select the grou cluster p by clicking on its *select button [O]* on the *Sonification control* section of the *Main panel*.
- Click on the circles you wish to assign to a cluster on the video. You should see the circles the color of you selected cluster.

*Removing* an ROI from a cluster up :

- Enter *Del mode* clicking on the *Del mode* button on the *Main panel*.
- Click on the ROI to remove from a cluster on the video.

*Setting a note* for a cluster:

- Select the cluster by clicking on its *select button* on the *Main panel*.
- Click on the note on the *piano* on the *Main panel*.

You can save and load sets of notes with the *Write notes* and *Read notes* buttons on the *Main panel*.

Alternatively, you can set the note in the *sonificaiton control* section.

*Monitoring* signals :

- Click the *Graphs* button on the *Main panel*.
- Click the *Select* button and click on the ROI on the video, or select the group in the menu
- The same process applies to the graphs displayed on the main panel.

You can pause/unpause the writing by clicking on the *on/off* button.

*Using predefined clusters* :

- Load the clusters : click *Load cluster file* on the *Main panel*.

When using cluster groups the groups you made are not overwritten, thus you can freely switch from one to another.

## ***Modifying the mapping***

You can modify the mapping using the *Mapping panel*. All the actions described on this part take place on this panel.

### 1) Mapping to the modulation index

On the bottom line of the flow chart you can change the mapping to the modulation index. This parameter of the FM synthesis is what makes a brighter, more metallic sound. The default mapping is the mean speed of the whole cluster.

The two menu in the *Modulation index mapping* line allow you to select which parameter of the data set will drive the modulation index, and thus will have an effect of the outcoming sound.

The two *scaling curves* describe the relation between the chosen parameter and the modulation index and can be used , they make an input value correspond to an output value.

- The first curve scales the choosen parameter : it can be used as a threshold setting the curve at zero until a certain value, enhance the higher values or the lower values, or disable the parameter from going above a certain value.
- The second curve controles the scaling of the modulation index, it makes the scaled parameter value corresponds to a modulation index value.

### 2) Mapping to the amplitude

The value of the signal of the ROI is used to control the amplitude, thus the loudness of the outcoming sound. The signal goes through a *sharpening* and a *scaling curve*.

The signal is scaled using a *scaling curve* which is to enhance the perception of the activation by obtaining a more « clicky » sound. Having a great value close to zero will result in increasing the variation in the sound, whereas a low value would smooth the transition.

The *sharpening* consists of adding its speed (first derivative) to the signal. It is used to enhance the perception of the moment when the ROI gets active by increasing the variations. The speed is scaled by the curve below. The *number box* is the amount of speed added to the signal.

### 3)Mapping to the detune

The detune effect is mapped to the difference in the group activity between the hemisphere.

The only quantity available for computation is the fluorescence. Two processing are avaiable : *activation ratio* and *average in group*.

The number box allows the user to set the range of variation : with *f* the note, *a* the coefficient, the new frequency varies between *f-af* and *f+af* .

## ***Switching clusters***

Three sets of clusters are implemented : clusters, handmade and left/right. Beside the default configuration, the three of them works on the same principle.

- *Cluster* is the default set. It is filled with a default set of clusters
- *Handmade* is empty by default
- *Left/right* is constituted of two clusters corresponding to the left and right hemisphere.

You can switch clusters by selecting the desired set in the menu, on the main panel.

# III – Troobleshooting

First of all, if you have any sound issue please check your audio driver is up to date and your hardware is working fine. The patcher is CPU intensive, thus it is recommended to close any other application.

### 1) Sound issues

Bad sound, crackling sound

- Check the CPU usage from the *audio status*
  - go to option>audio status
  - check the CPU usage
  - if the cpu is at 100 %, decrease the sampling rate and increase both I/O vectors and signal vector size
- Try different *Drivers* and repeat the process if the problem is not solved
- If the problem persists and the cpu hits 100 % load, you can unselect some ROIs to reduce the amount of audio processing.

No sound

- Check whether audio is ON: the *DSP button* on the *Main panel* must be highlighted.
- In the *audio status*, check whether the correct *output Device* (i.e. the output of your computer or sound card) is selected.
- Check whether ROIs are allocated to groups : an unallocated ROI will not produce any sound.

- Check whether your data has been loaded : the message « Read_new_data» should have appeared in the console.
- Check whether the data has been processed : based on the selected normalization and treatment two messages should have appeared in the console, if they have not, relaunch the normalization or restart Max (especially for the running average) :
    - normalized_by_[method]
    - [method]_preprocessed

Some Rois do not produce sound

- Reload the ROI set.
- Lower the standard deviation coefficient in the *Mapping panel.*
- Move the *scaling curve* on the top line of the *Mapping panel* to the right.

### 2) Video issues

No video

- Check the video was successfully loaded. The message « read [video name] 1 » should have appeared in the console.

Strange ROI placement

- Reload the video.
- Reload the ROIs.

Slow video/bad synchronisation between video and sound

- Go to option>audio status.
- Turn down *Sampling rate.*
- Turn up the *vector sizes*